PEACE/WILLISTON
FISH & WILDLIFE
COMPENSATION
PROGRAM

BC hydro

BRITISH COLUMBIA

Dinosaur Lake Aquatic Plant Enhancement Potential

AIM Ecological Consultants Ltd.
May 2000

PWFWCP Report No. 259

The Peace/Williston Fish & Wildlife Compensation Program is a cooperative venture of BC Hydro and the provincial fish and wildlife management agencies, supported by funding from BC Hydro. The Program was established to enhance and protect fish and wildlife resources affected by the construction of the W.A.C. Bennett and Peace Canyon dams on the Peace River, and the subsequent creation of the Williston and Dinosaur Reservoirs.

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This report has been approved by the Peace/Williston Fish and Wildlife Compensation Program Fish Technical Committee.

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Peace/Williston

Fish & Wildlife Compensation Program

Dinosaur Lake

Aquatic Plant Enhancement Potential

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1. INTRODUCTION

The Peace/Williston Fish and Wildlife Compensation Program (PWFWCP) is a joint initiative between BC Hydro and the BC Ministry of Environment, Lands and Parks, developed initially to mitigate the impact of the W.A.C. Bennett Dam, and later expanded to fund fisheries projects in the Dinosaur Reservoir watershed. Impoundment of the Peace River to produce both Williston and Dinosaur Lakes, resulted in the flooding of shoreline wetlands and low gradient sections of tributary streams resulting in a reduction in the amount of available fish habitat. Specific fish-related objectives of the Compensation Program, are:

- to sustain and enhance fish and wildlife populations affected by BC Hydro's hydroelectric development.
- to use compensation funds effectively for the benefit of fish and wildlife in the program area.
- to take a long-term view of providing benefits to the fish and wildlife resources of the area.

As part of an overall objective to benefit fish populations, AIM Ecological Consultants Ltd. (AIM) was requested by the PWFWCP to assist with a long term goal of re-establishing aquatic plant growth in Dinosaur Lake. The initial tasks included identification of:

- vegetation species suitable for transplant within a reservoir with daily water fluctuations, and
- sites within Dinosaur Lake suitable for sustaining plant growth.

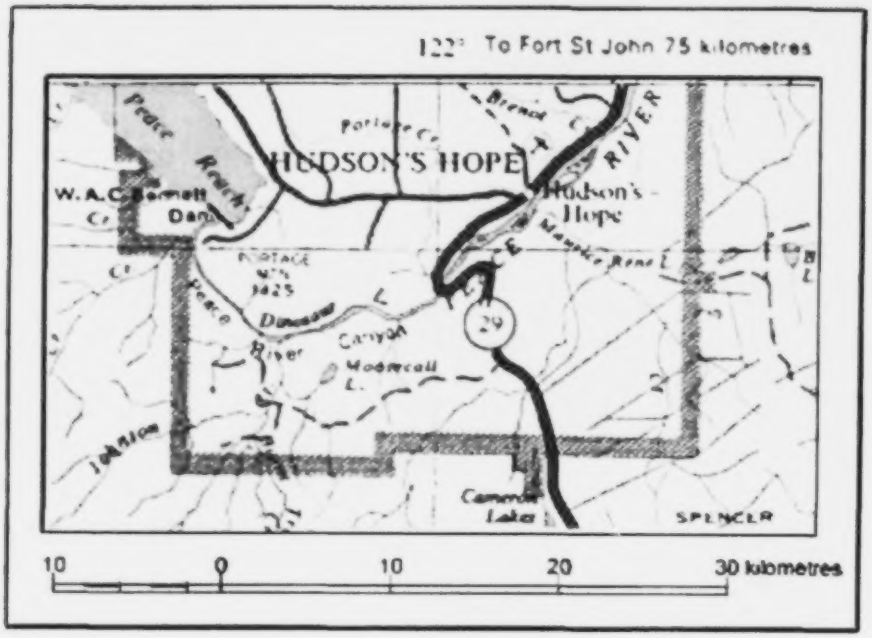
Specific terms of reference for the project, were as follows:

> *Conduct a site visit to Dinosaur Reservoir to determine the feasibility of transplanting aquatic plants into sites within the reservoir. Produce a short report documenting plant species present and a recommended course of action to establish aquatic plants in the reservoir.*

As a separate project, the PWFWCP contracted with CRV Greenhouse to provide 600 cattail seedlings for a growth trial at Johnson embayment. The planting of the cattail plugs occurred at the same time as the field inventory for this study. A description of the cattail planting trial is included in this report to provide a thorough description of the vegetation resources within the reservoir at the time of the field visit.

Aquatic vegetation, both submergent and emergent, is able to provide fish, in general, with spawning, nursery, cover and feeding habitat. The amount of habitat provided depends on the species and age of fish as well as the species, growth form, density and water depth of the vegetation community (Appendix 1). Reservoirs in B.C. tend to have relatively barren shorelines compared to natural lakes due to water level fluctuations and associated draw down zone stresses. Establishment of aquatic vegetation in the drawdown zones of reservoirs has been undertaken in several reservoirs in B.C. and in the Pacific Northwest for fish and wildlife enhancement as well as dust control. Natural colonization of drawdown areas appears to be limited by the inability of plants to initially establish in the extremely variable environments. However, planting of greenhouse grown stock or mature plants has proven to be successful in several locations. The intent of this preliminary study was to examine the shoreline of Dinosaur Lake to identify suitable sites and species for habitat enhancement.

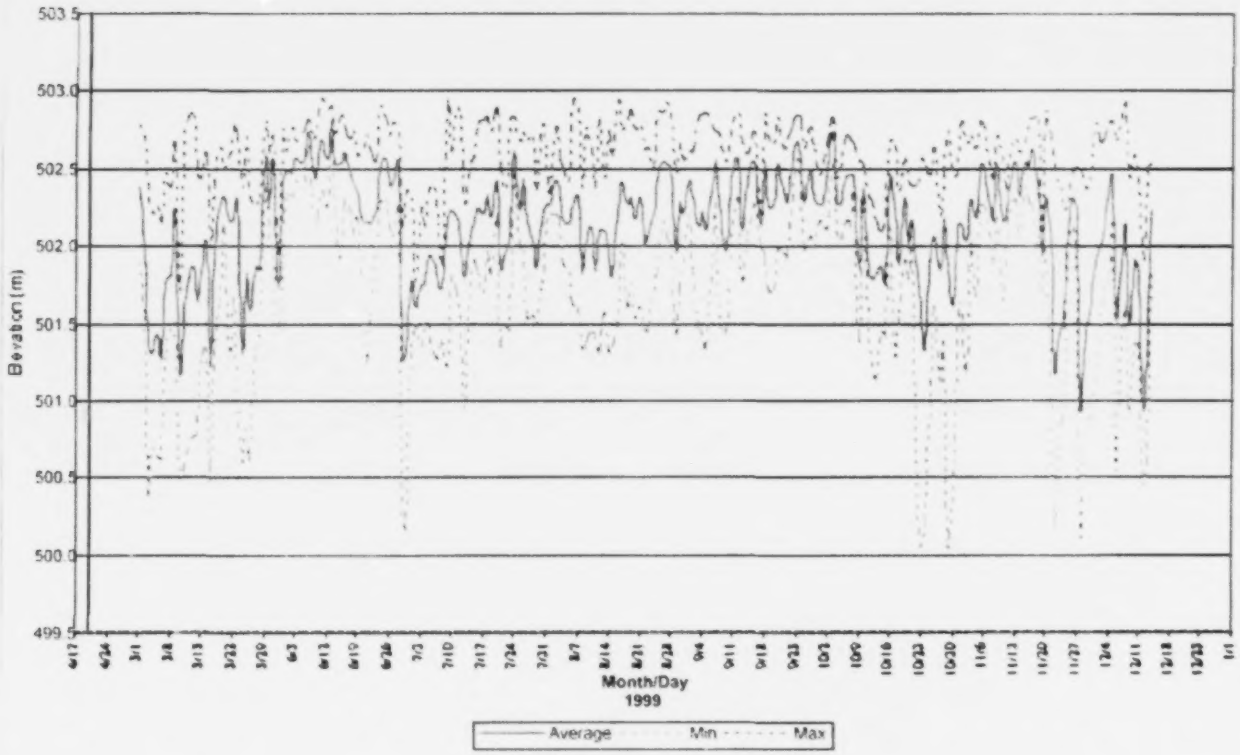
Figure 1: Location of Dinosaur Lake



2. BACKGROUND

Dinosaur Lake was created between 1975 and 1979 with the construction of the Peace Canyon dam on the Peace River, 21 km downstream of the W.A.C. Bennett Dam (Figure 1). Peace Canyon operates as a run of river project with daily water level fluctuations in the order of 0.5 to 2.5m (1m average 1999) with Williston Lake providing the water storage capacity (Figure 2). Water temperatures in Dinosaur reservoir are moderated by surface and hypolimnetic withdrawal from Williston Lake and typically range from 1 - 4°C in winter to about 15°C in summer. The 805 ha reservoir is confined for the most part by steep-sided valley walls which are subject to erosion and slumping (Figure 3). Very little aquatic vegetation, either submergent or emergent, is found along the shoreline of the reservoir.

Figure 2: Daily Water Level Fluctuations in Dinosaur Lake, 1999



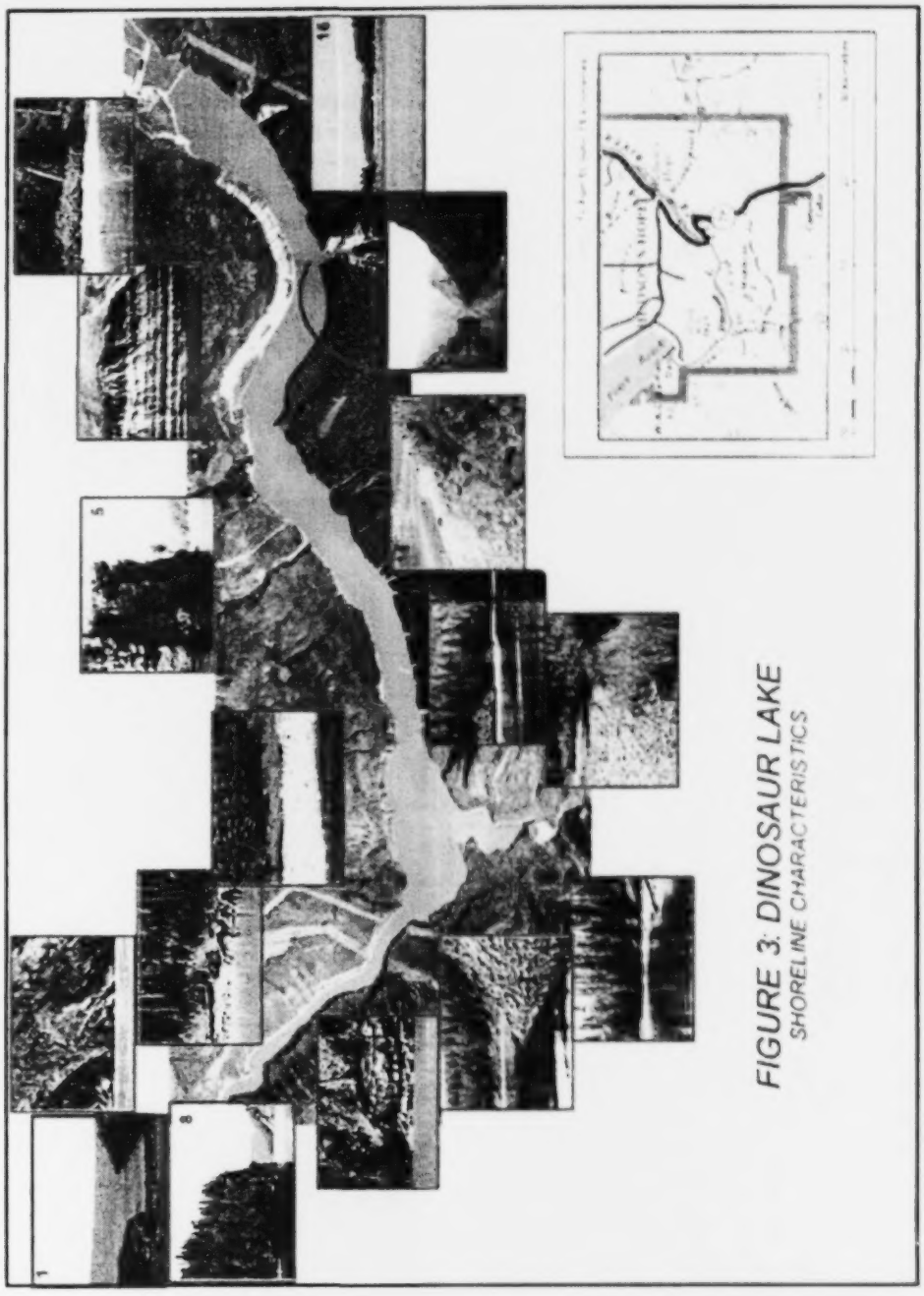


FIGURE 3: DINOSAUR LAKE
SHORELINE CHARACTERISTICS

Annotations for Figure 3: Shoreline Characteristics

Insert Image Number	Description *Images are from video taken during boat survey of July 6, 1999*
1	W.A.C. Bennett Dam viewed from Dinosaur Lake
2	Steep bedrock shoreline near W.A.C. Bennett Dam
3	Embayment with gentle slope and numerous stumps
4	Relatively gently sloping cobble shoreline with native vegetation occupying upper beach zone
5	Steep sided cliff along south shore
6	Eroding slopes along northern shore
7	Gently sloping, fine textured beach near boat launch
8	Steep cliff face in western reach of reservoir
9	Steep cliff face in western reach of reservoir
10	Steep cobble shore at mouth of Johnson Creek embayment
11	Gradual slopes in Johnson Creek embayment
12	Shoreline vegetation and silt deposits in Johnson Creek embayment
13	Gradual slopes in Johnson Creek embayment
14	High energy shoreline facing west in small bay on southern shore of reservoir
15	Starfish bay, steep sided valley walls
16	Peace Canyon Dam

Creation of the reservoir resulted in the flooding of low gradient sections of Peace River tributary streams that were originally utilized by fish for spawning and rearing, reducing the amount of available fish habitat. Wetlands situated in the valley bottom, adjacent to the river, were also flooded by the reservoir. Streamside wetland habitats are generally valued for their food production capacity and as rearing habitat for juvenile fish.

The sport fishing catch data from Dinosaur Lake reflect changes in the water body as a result of the impoundment and hatchery stocking. A notable difference between the sport fish results from pre-impoundment and also the downstream Peace River is the absence of arctic grayling and northern pike in the reservoir fishery (Table 1). Pike, in particular, are known to require wetland habitats for at least a portion of their lives. Their absence from the population may reflect the changes in habitat availability as a consequence of reservoir creation.

Table I: Sport Fish Caught in the Peace River and in Dinosaur Reservoir
(derived from Hirst 1991)

Pre-impoundment[1]	**5 years Post-impoundment**	**Downstream Peace River**[2]
rainbow trout (36%)	rainbow trout (44%),	rainbow trout
lake whitefish (29%)	lake whitefish (32%)	
mountain whitefish (14%)	mountain whitefish (14%)	mountain whitefish
bull trout (5%)	bull trout (8%)	bull trout
arctic grayling (4%),		arctic grayling
northern pike (2%)		northern pike
		walleye
	kokanee (2%);	

[1] Ash1976a,b in Hirst, S. M.1991. Impacts of the Operation of Existing Hydroelectric Developments on Fishery Resources in British Columbia. Volume II Inland Fisheries. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2093.

[2] Thurber Ltd. 1976, Renewable Resources Ltd 1979 in Hirst, S. M.1991. Impacts of the Operation of Existing Hydroelectric Developments on Fishery Resources in British Columbia. Volume II Inland Fisheries. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2093.

In order to determine the feasibility of transplanting aquatic plants into sites within Dinosaur Lake, AIM assembled any available information (plant species records for the area, fish habitat information, regional lake survey information, photographs) prior to the field visit. The site visit at a time when plants were fully developed (to facilitate identification). Specifically the tasks were as follows.

Pre-field

- assemble all relevant information prior to the field visit
- examine stereo pairs of aerial photographs for any submergent vegetation beds.
  (Unfortunately, aerial photos were not available until after the field visit, these were examined later)
- examine hydrological data for the reservoir
  (not available until after the field visit, examined later)

Field:

Site inspections of the shoreline of Dinosaur reservoir were undertaken on July 6, 1999 by boat. The entire shoreline was videographed and characterized for vegetation development potential. Plant description was undertaken at several potential enhancement locations.

In addition, two downstream sites were visited on the Peace River to evaluate plant species composition in the shoreline areas. Trapping Lake was visited to identify aquatic plant species in a potential donor area. Several other lakeshore areas along the Highway 29 corridor were viewed to determine plant species distributions.

Post-field

- stereo pairs of aerial photographs were examined for any submergent vegetation beds.
- Photo-mosaic of reservoir prepared from air-photos (Figure 1,3)
- hydrological data for the reservoir examined
- video transferred to VHS format
- video capture of select shoreline images for Figure 3
- preparation of report

TRAPPING LAKE

Trapping Lake was visited as a representative nearby waterbody and as a potential donor site for plant material. The water levels at this lake appear to be relatively stable and therefore the plant species are not subject to the same types of stresses as experienced in the reservoir.

Aquatic plant identification was limited to shoreline accessible viewing. Yellow pond lily *(Nuphar* sp.), burreed *(Sparganium* sp.), water smartweed *(Polygonum amphibium),* pondweeds *(Potamogeton robbinsii, P. natans)* and stonewort *(Chara* sp.) occurred in the shallows of Trapping Lake (Figure 4). Several species of sedge were noted along the aquatic/terrestrial interface. Spike-rush *(Eleocharis palustris),* marsh cinquefoil *(Potentilla palustris)* and lesser-panicled sedge *(Carex diandra)* occurred lowest in elevation, at the water line, with water sedge (*C. aquatilis),* beaked sedge (*C. rostrata)* water arum (*Calla palustris)* and inflated sedge (*C. exsiccata)* forming the next higher zones.

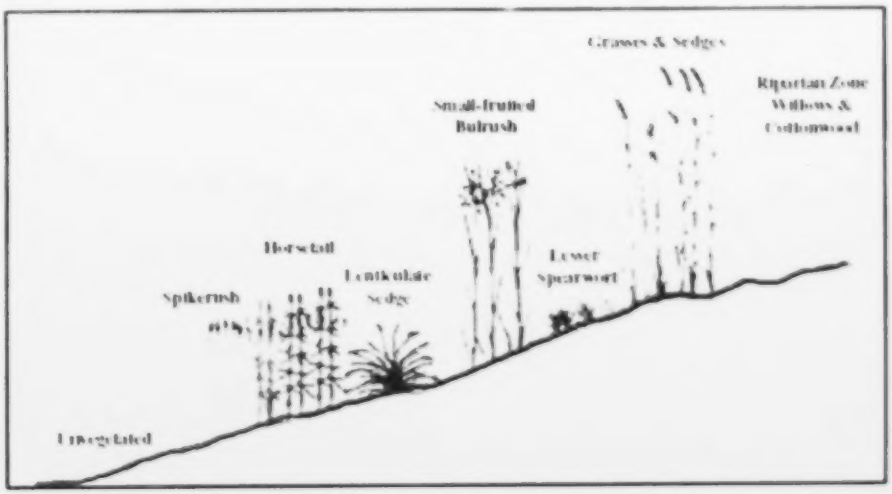
Figure 4: Trapping Lake Shoreline View

PEACE RIVER SHORELINE VEGETATION

Shoreline vegetation along the Peace River, downstream of Hudson's Hope was examined to provide an indication of pre-reservoir conditions at Dinosaur Lake. Although water levels in the river are regulated by the Peace Canyon Dam, the water-level fluctuations are irregular (in the range of 1.5m) compared to the upstream reservoir. Below the dam, the river changes to a braided system with many islands. Erosion and sedimentation occur along the stream banks.

Plant species were examined at the Halfway River mouth, on a soft mudflat that had been the recipient of a significant amount of silt deposition. Wildlife sign revealed use of this area by geese, elk and deer. The riparian zone was characterized by willow and cottonwood at upper elevations.

Figure 5: Characteristic Shoreline Profile in Halfway /Peace River Junction.



The predominant species at this location included several grasses at the highest elevations, the most common of which was reed canary-grass *(Phalaris arundinacea)* and bluejoint *(Calamagrostis canadensis)*. Lesser spearwort *(Ranunculus reptans)* formed a patchy ground cover, slightly lower in elevation than the grasses. Continuing over a gradual elevation gradient, from high to low (Figures 5, 6, 7 & 8) were patchy distributions of small-fruited bulrush *(Scirpus microcarpus)*, *water sedge (Carex aquatilis)*, beaked sedge *(Carex rostrata)*, inflated sedge *(Carex exsiccata)*, lens-fruited sedge *(Carex lenticularis)* and at the lowest elevations, bands of swamp horsetail *(Equisetum fluviatile)* and needle spike-rush *(Eleocharis acicularis)*.

Figure 6: Peace River Halfway River view to West

Figure 7: Peace River Halfway River view to southwest

Figure 8: Lens-fruited sedge (Carex lenticularis) along shoreline of Peace River

Sites closer to the Peace Canyon Dam displayed less diversity of species, but had good shoreline vegetation cover consisting primarily of lens-fruited sedge and swamp horsetail. A mix of grasses occurred high along the banks where inundation was infrequent.

Lens-fruited sedge (Figure 8) has been consistently observed in fluctuating water regime habitats throughout B.C. It has proven to be one of the more successful species for revegetating reservoir drawdown zones.

JOHNSON CREEK EMBAYMENT

Pre-impoundment, Johnson Creek was considered to be a major rainbow trout spawning and rearing area. Logging activity resulted in siltation of the creek and about 35% of the fish accessible area was lost due to inundation with the creation of Dinosaur Lake. The shallows at the mouth of Johnson Creek are still showing signs of moderate to heavy silt deposition (Figure 9).

Within the draw down zone, a narrow band of emergent vegetation was observed between the riparian shrub zone and the barren silt deposits (Figure 10). This consisted primarily *of water sedge (Carex aquatilis)* (Figure 11), beaked sedge *(Carex rostrata),* grey sedge *(Carex canescens)* (Figure 12), tufted hairgrass *(Deschampsia caespitosa)* and fowl bluegrass *(Poa palustris).*

Figure 9: Johnson Creek Embayment, view to south (creek mouth)

Figure 10: Johnson Creek Embayment - Shoreline vegetation

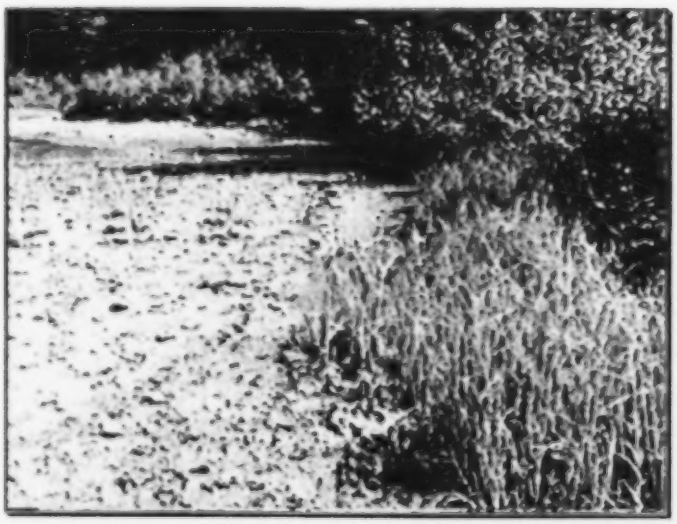


Figure 11: Water-sedge at Johnson Creek embayment

Figure 12: Gray sedge at Johnson Creek embayment

OTHER SITES

Several other sites were visited during the course of the shoreline survey. Submergent aquatic plants such as pondweeds, water milfoil or bladderwort were not observed in any of the likely locations (sheltered bays, shallow water sites - e.g. Figure 13) within the reservoir.

The absence of the submergent aquatic plants may be in part due to the water level fluctuations and desiccation during daily exposure periods or it may be related to the wave energies and currents found in the long narrow reservoir. An absence of previously existing seed banks and a lack of waterfowl utilization may have restricted the development of an aquatic plant community. Establishment of any kind of submergent plant community will be dependent on providing sheltered habitats for the plants to occupy and source material for potential expansion.

Figure 13: Shallow water bay (near insert #4 - Figure 3) no submergent aquatic growth

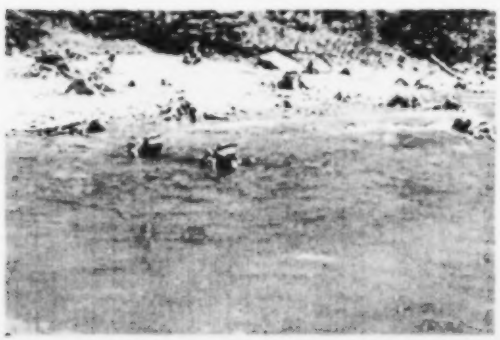


Figure 14: Rock shoreline, no aquatic vegetation development

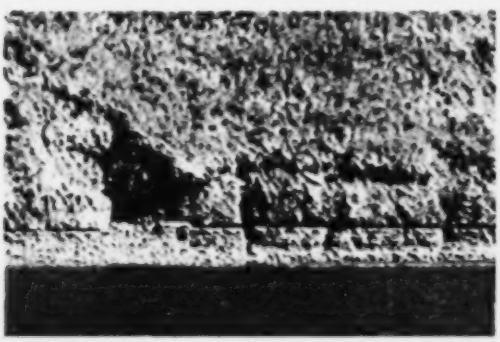


Figure 15: High-energy gravel beach, vegetation development only above high water mark

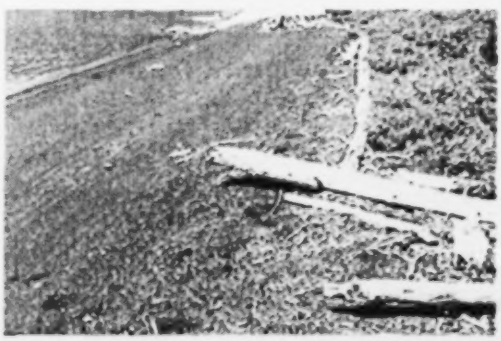
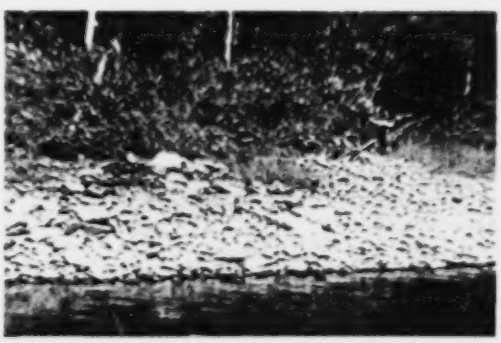


Figure 16: Coarse cobble shore limits vegetation growth



Emergent vegetation was absent along much of the shoreline of Dinosaur Lake, either as a result of; steep slopes (Figure 14) or a high degree of erosion. Where shoreline emergent vegetation was present, it was restricted to a narrow band by high wave energy (Figure 15), steep shoreline, or coarse substrates (Figure 16).

Two shallow bays along the south shore of the reservoir (Figure 25, Site 2 a & b) were inspected for enhancement potential as they appeared to offer gentle slopes and fine textured substrates ideal for vegetation establishment. However, they seem to have restricted vegetation development as a consequence of extreme wind, wave and probably ice action. A steep beach escarpment (Figure 15) characterized the west facing shorelines of these bays and heavy erosion (Figure 17) was apparent in some areas. The existing shoreline vegetation in these areas is only present at or above the highest water levels as evidenced by the remains of last year's organic litter amid current growth. Plant diversity was high with a range of forbs and grass species. The east-facing shores of these bays offer gradual slopes and have the potential for vegetation establishment. Currently there is very little shelter available in these bays for the schools of young fish observed in the shallows (Figure 18).

Figure 17: Erosion of established vegetation in high-energy environment

Figure 18: Schools of young fish in shallows of Site 2b, south side of Dinosaur Lake.

Two shallow bays along the north shore of the reservoir (Figure 25, Site 4 a & b) appeared to offer gentle slopes and a relatively sheltered environment (Figure 13). Coarse substrates appear to be restricting plant distribution in all but a few small pockets at these sites (Figure 16). Isolated areas may offer potential for emergent vegetation enhancement but the greatest potential appears to be for submergent vegetation development.

5. PRELIMINARY TEST PLOTS

Ongoing concurrently with the field survey in July 1999, was a separate trial program to plant 600 cattail *(Typha latifolia)* seedlings at the Johnson Creek embayment. Greenhouse grown cattail seedlings were planted into silt substrates across a range of elevations at the mouth of Johnson Creek.

Figure 19: Installation of cattail seedlings

Figure 20: Individual cattail seedling

Figure 21: Cattail seedlings at Johnson Creek

During the field survey, it became apparent that a small test plot would be beneficial to determine the potential for transplantation of sprigs of the local sedge and grass species. The test plot was established across an approximately 2-m gradient in the exposed sediments at the mouth of Johnson Creek (Figure 22 & Figure 23). A total of 60 sprigs (approximately 7 cm in diameter and 20 cm deep) were excavated from the nearby emergent vegetation community and transferred to the adjacent unvegetated silt deposits (Figure 24). Three species were transferred: 24 sprigs of beaked sedge *(Carex rostrata);* 24 sprigs of water sedge *(Carex aquatilis)* and 12 sprigs of fowl bluegrass *(Poa palustris).*

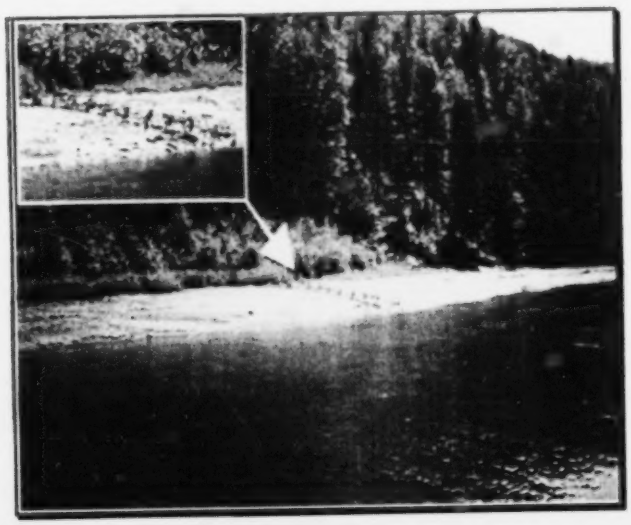
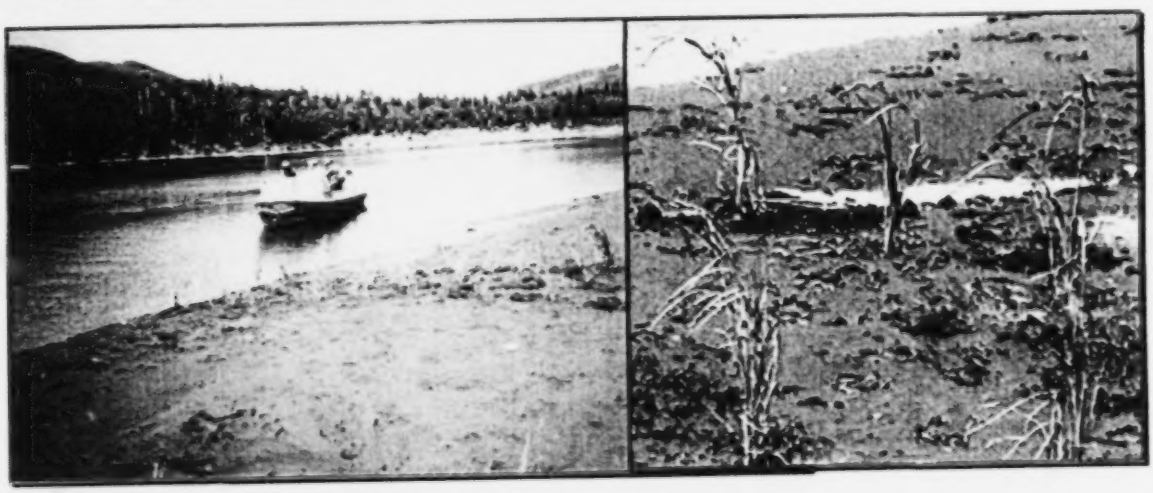


Figure 22: Sedge and grass test plot at Johnson Creek.

Figure 23: Johnson Creek sedge transplants

Figure 24: Close-up of Johnson Creek sedge transplants



A visit to the site in the fall of 1999 while the test plot was partially inundated revealed that the sprigs had survived the initial transplant and had experienced continued growth. Future monitoring is recommended to determine long-term success of these transplants.

6. DISCUSSION

Prior to embarking on a major planting operation, it is essential to determine how local environmental variables are currently restricting plant distributions. Preliminary test plots established at Johnson Creek should provide some baseline information about the tolerance levels of transplanted sprigs. Results to date are consistent with the findings from other reservoirs; i.e. the transplanted vegetation is showing a tolerance of a greater range of water depths than the native plant distributions would suggest. Establishment seems to be the essential factor in limiting plant expansion within the drawdown zone.

In general, the water regime of reservoirs dictate the level in the drawdown zone to which vegetation can be expected to grow. Changes in the duration and pattern of exposure in inundation can cause severe disruption of plant growth patterns and ability to establish. The preliminary trial at Johnson Creek utilized sprigs harvested from adjacent shoreline vegetation. The results of this trail will demonstrate the ability of the existing vegetation community to respond to environmental change. In the overview of Dinosaur Lake shorelines, it was apparent that the emergent vegetation abundance and species diversity was very limited. Adjacent wetlands were visited to determine the presence of other wetland species for potential enhancement of the reservoir. Based on experimental programs in other reservoirs, it is recommended that additional plant species, native to the local area, be tested for their tolerance of hydrologic conditions in Dinosaur Lake (Section 7). Ideal emergent vegetation candidates are lens-fruited sedge, bulrush, and tufted hairgrass. Submergent aquatics will need to be provided with anchoring means and should be restricted to species occurring at present within the adjacent watershed.

Potential Vegetation Establishment Sites

Several sites were identified as potential candidates for further investigation (Figure 25). Although all of them offer some potential for plant establishment, they also have some restrictions to growth in addition to water level fluctuations.

Site 1 - Johnson Creek

At Johnson Creek (Site 1), a major variable is the rate of silt deposition. Are the plants able to withstand potential smothering? Ice scouring and high wave energies are other variables to consider. This embayment appears to be relatively sheltered from intense currents and thus appears to have a relatively benign environment for plant growth. For this reason and the historical fisheries values of this site, Johnson Creek ranks most highly as a candidate for vegetation enhancement.

Considerations for enhancement potential

- *Low energy bay*
- *High silt deposition area (potential for plants to enhance deposition)*
- *Shallow gradient*
- *Fine substrates*
- *Historical fisheries values*

Figure 25: Potential Aquatic Vegetation Enhancement Locations

Site 2 a & b - South Side Bays

The east-facing shores of these bays offer gradual slopes and have the potential for vegetation establishment, particularly if some form of shelter is provided. This could be in the form of a breakwater, or shear-boom.

Considerations for enhancement potential

- *High energy - wind and currents impinging on westfacing shore*
- *Potentialfor breakwater*
- *Shallow gradient*
- *Fine substrates on east and northfacing shores*
- *Lack ofcoverforfish currently utilizing area*

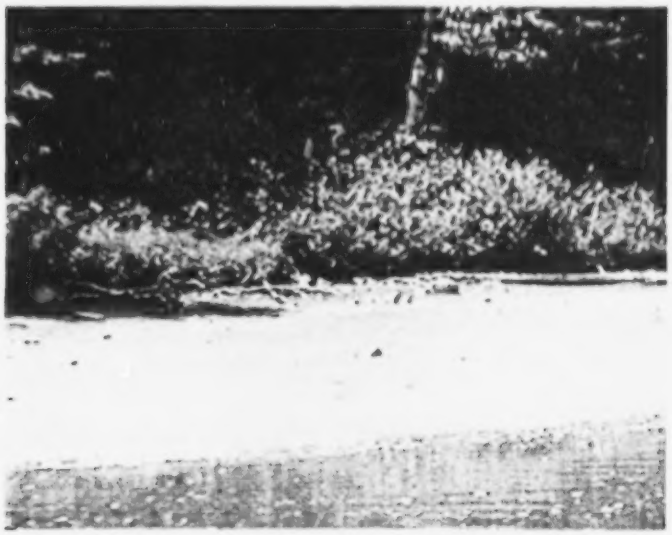
Site 3 - Boat Launch Area

The greatest opportunity for vegetation enhancement outside of the Johnson Creek embayment appears to be immediately west of the boat launch area where a gently sloping shoreline appears to be an ideal candidate for vegetation trials. The energy environment, shallow gradient and substrate conditions at this site appear to favour aquatic vegetation development. The only negative aspect of this site is its proximity to public use, which could result in vandalism or disruption of vegetation plantings. However, the proximity to the park can also be considered of benefit since any vegetation development here would be an asset to the aesthetics of the site.

Considerations for enhancement potential

- *Low energy bay*
- *Shallow gradient*
- *Fine substrates*
- *Human factor (potentialfor vandalism)*
- *Aesthetic benefitsfor adjacent public use areas*

Figure 26: Shoreline view, boat launch area



Site 4 a & b - North Side Bays

Two shallow bays along the north shore of the reservoir (Figure 25, Site 4 a & b) appear to offer gentle slopes and a relatively sheltered environment. The energy environment needs to be examined more closely in light of the absence of shoreline fines. Coarse substrates appear to be the main restrictive factor for plant distribution. The greatest potential appears to be for submergent vegetation development.

Considerations for enhancement potential

- *Low energy bays (?)*
- *Shallow to moderate gradient*
- *Coarse substrates, with fines in some locations*
- *Suitable for submergent aquatics in some locations*

7. RECOMMENDATIONS FOR VEGETATION TRIALS AT DINOSAUR LAKE

Vegetation investigations and plant trials at several of B.C. Hydro's reservoirs have demonstrated that native vegetation growing naturally within a reservoir may not be extending to its full inundation tolerance potential. In most reservoirs, the survival of native vegetation is severely limited by extended inundation, sometimes several months in duration. However, the daily water level fluctuations of up to 3 m experienced in Dinosaur reservoir offer unique circumstances for plant growth which have not been explored in the vegetation trials conducted in other reservoirs. Due to the steepness of the shorelines and the apparent high energy environment occurring in the shoreline areas, the opportunities for enhancing shoreline vegetation within the reservoir are limited to a few shallow embayments.

To continue the assessments of vegetation potential initiated this year, three test plots are recommended to be chosen from among the potential locations identified for Dinosaur Lake (Section 6). Based on previous reservoir experience, and observation of the species present in the reservoir and adjacent areas, the following species complement is suggested for the trials: Lens-fruited sedge *(Carex lenticularis),* water sedge *(C. aquatilis),* bulrush *(Scirpus fluviatilis)* and tufted hairgrass *(Deschampsia caespitosa).* For emergent plants, a randomized block design (3 locations, 2 elevations, 5 species, and 75 replicates) is suggested. The number of plants required to achieve this design would be 600 of each species for a total of 2250 seedlings. Submergent plant species were not observed in shallow water areas of Dinosaur reservoir during the field visit. However, with some protection from currents and wave action, it is likely that submergent beds could be established in selected areas to provide cover for fish. The use of concrete blocks for anchoring of submergent plant propagules may prove to be a cost-effective method of achieving protected submergent vegetation beds. Limited test plots are recommended to evaluate the success of this method with suitable species of submergent plants (e.g. *Potamogeton alpinus, P. gramineus, P. zosteriformis, Ranunculus aquatilis, and Utricularia vulgaris).*

Transplant material (seedlings) from seeds collected on site may be grown hydroponically in the greenhouse, under a mixture of artificial and natural light. Prior to transplanting into the natural environment, seedlings would be "hardened" to outdoor conditions. Planting would occur as soon as conditions permit in the Dinosaur Reservoir area, and when seedlings are of suitable size (anticipated to be June). Planting would be undertaken by a field crew experienced in seedling transplants. Monitoring of seedling establishment is recommended approximately 90 days after the initial transplant.

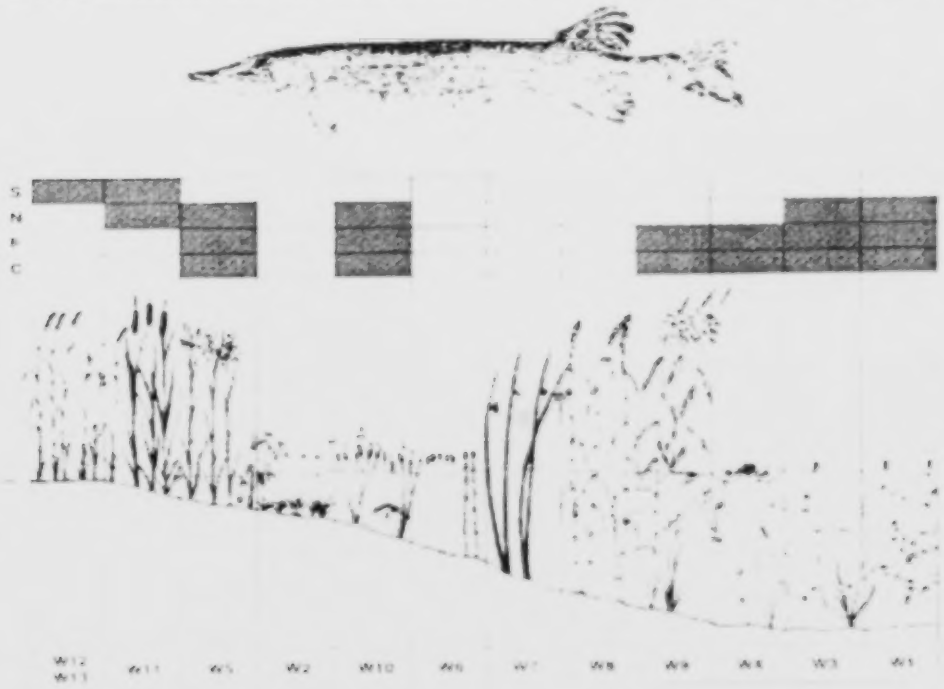
	Emergents	Submergents
Locations	3	3
Species	5	4
Elevations	2	
Replicates	75	25
Total Number Of Plants	2250	300

APPENDIX 1: FISHERIES VALUES OF AQUATIC VEGETATION

Wetlands are generally assumed to be important habitats for fish, but this assumption has a meager factual base; documentation of habitat use is poor for most fish species, particularly in British Columbia for salmonids. Recognition of a similar lack of information in Ontario resulted in a publication[3] which incorporated a wetland classification system (Wetland Ecosystem Classification for Northwestern Ontario NWO WEC) and a framework for assessing fish habitat values of wetland communities. The publication notes that of 90 species of fish, known to occur in northwestern Ontario, 40 are known or thought to use wetland habitats for spawning, nursery, cover or feeding. Of the species included in this report, few are common to both northern Ontario and B.C. An example of specific wetland use by northern pike as detailed in the publication follows. The wetland classification system and the fish use of habitat types is presented here to provide an example of shoreline vegetation complexity and fish use. Unfortunately, no such information is available for rainbow trout or bull trout.

NORTHERN PIKE *Esox lucius*

Northern pike occur in a wide range of habitats, but prefer clear, warm, vegetated bays of lakes or slow, meandering rivers. Optimum cover consists of extensive submergents and/or emergents (25-50%cover) interspersed with open water (Keast 1978, Toner and Lawler 1969). They are often found at the open water-vegetation inter-face in 3-6 m of water where ambush cover and food are maximized. Northern pike spawn in spring on heavily vegetated floodplains, often in 18 cm or less of water (Fago 1977, McCarragher and Thomas 1972). Optimum spawning habitat is a dense mat of sedges, cattails or grasses with a large basal coverage for egg adhesion and which keep eggs out of the sediment where oxygen is low. Slender naiad is used for spawning, but water milfoil and coontail are not desirable. Larvae attach to vegetation for six to ten days using an adhesive pad. Young pike prefer submerged vegetation; rooted aquatic plants offer cover and increased plankton, and therefore the best food supply. In late summer, juveniles move to emergent vegetation where dissolved oxygen levels are higher (Holland and Huston 1984). Northern pike under about 50 mm eat invertebrates; larger individuals are primarily piscivorous.



[3] Hall-Armstrong, J., A.G. Harris, and R.F. Foster. 1996. Fish Use of Wetlands in Northwestern Ontario: A Literature Review and Bibliography. Northwest Sci. & Technol., Ont. Min. Natur. Resour., Thunder Bay, Ont. TR-90. 54 pp.

S - Spawning N - Nursery F - Feeding C - Cover

APPENDIX 1: Fisheries Values of Aquatic Vegetation (continued)

Northwestern Ontario Wetland Ecosystem Classification W-type Descriptions

The Northwestern Ontario Wetland Ecosystem Classification (NWO WEC) (Harris *et al.* 1996) was developed to provide resource managers with an ecologically-based means of making decisions about wetland management. NWO WEC covers the full range of wetland conditions including bogs, fens, swamps, marshes and open water wetlands (National Wetlands Working Group 1988; Jeglum *et al.* 1974). Wetland plant communities (W-types) were described to the "ecoelement" level (Uhlig and Baker 1994) through a process of field data collection and data analysis (Harris 1995). Keys to the W-types, based mainly on plant indicator species, are provided.

The W-types describe "local" wetland plant communities on the basis of 25 square metre plots, although they may cover many hectares. A given W-type is often found associated with other wetland plant communities in a predictable sequence. Larger wetland areas may be described as complexes of W-types.

The following are descriptions of the wetland plant community types (W1-W13) which make up potential fish habitat. Wetland community types consisting of bogs, fens and swamps (W14-W35) have little direct habitat value to fish and are not listed.

W1 Open water marsh: mixed: mineral substrate
Open water marsh with variable species composition. Emergent cover less than 25%, but includes marshes with sparse emergents and low submergent cover. Floating leaf cover less than 50%, usually much lower. Often dominated by a single species such as pondweeds *(Potamogeton gramineus, Potamogeton zosteriformis),* coontail and others. Water depth usually >50 cm. Substrate is mineral soil, often sand, or a mixture of sedimentary peat and fine mineral soil. Wave-washed shores.

W2 Open water marsh: pipewort water lobelia: mineral substrate
Shallow, sparsely-vegetated, open water marsh. Dominated by plants with basal rosettes of leaves resistant to wave energy. Water depth usually < 50 cm. Substrate consists of sand, or organic and mineral material trapped between boulders or in bedrock crevices. Sandy, wave-washed shores or rocky, oligotrophic lakes.

W3 Open water marsh: mixed: organic substrate
Open water less than 1 m deep with emergent cover up to 25% cover, floating leaf cover up to 50%. Submergent cover variable, often high. Typically few plant species at a given location, but species composition variable. Often dominated by a single species such as coontail, stonewort, Canada waterweed, water milfoil, pondweeds *(Potamogeton richardsonii, Potamogeton robbinsii, Potamogetor zosteriformis)* and wild celery. Water depth usually > 50 cm. Substrate is sedimentary organic material. Sheltered bays of lakes and streams not highly disturbed by wave or current action.

W4 Open water marsh: floating-leaved plants
Open water marsh with emergent cover less than 25% and floating leaf cover greater than 50%. Typically few plant species (may consist of a single species), but plant species composition variable. Often dominated by a single species such as floating-leaved burreed (especially in slow-moving streams), water lilies and floating-leaved pondweed. Other locally common dominants are water shield and large-leaf pondweed. Water depth usually greater than 50 cm. Substrate is typically sedimentary organic material. Quiet lakeshores and slow-moving streams.

W5 Marsh: mixed: mineral substrate
Marsh with emergent cover greater than 25%. Variable species composition. Often dominated by a single species such as sweetflag, beaked sedge, burreeds and others. Submergent cover sometimes high. Water depth usually < 1 m. Substrate is mineral soil (often sand), sometimes held together by a dense root mat. Typically on wave-washed lakeshores and streams.

W6 Marsh: spikerush-water horsetail: mineral substrate
Spikerush and/or water horsetail marsh. Emergent cover variable, but >25%. Floating and submergent cover low. Water depth usually less than 1 m. Substrate is mineral soil (often sand), sometimes held together with a root mat. A layer of partly decomposed stalks may be present. Wave-washed lakeshores, sandbars, shallow streams.

W7 Marsh: bulrush: mineral substrate
Marsh dominated by hard-stemmed bulrush *(Scirpus acutus),* soft-stemmed bulrush *(Scirp? 's validus)* and/or river bulrush *(Scirpus fluviatilis).* Species poor. Floating and submergent cover low. Water depth variable. Substrate usually sand, sometimes finer mineral soil. May be held together by a mat of roots. Wave-washed lakeshores; occasionally on quiet lakeshores or stream margins.

W8 Marsh: common reed: mineral substrate
Common reed-dominated marsh. Narrowleaved cattail *(Typha angustifolia)* sometimes codominant. Floating and submergent cover low. Species poor. Water depth variable; up to 2 m. Usually on sand or other mineral substrate, sometimes with a dense mat of roots and partially decomposed stalks. Most frequent on wave-washed lakeshores, but also found in more sheltered areas including roadside ditches.

APPENDIX 1: **Fisheries Values of Aquatic Vegetation (continued)**

W9 Marsh: wild rice: organic substrate
Wild rice-dominated marsh. Other emergents uncommon. Floating leaf and submergent cover often high. Water depth usually > 50 cm. Thick mat of rice stalks often covers the bottom. Substrate rich sedimentary organic material. Deeper, sheltered waters of slow-moving streams and protected bays.

W10 Marsh: mixed: organic substrate
Species composition variable, but typically few plant species present at a given location. Often dominated by a single species such as arrowhead, burreeds and "broad-leaved emergents" (e.g. water plantain). Also includes recently exposed areas such as drained beaver ponds where water smartweed, nodding beggar's tick and other herbs are dominant. Water depth usually <1 m. Substrate is sedimentary organic material, sometimes mixed with fine mineral soil. Litter layer of partly decomposed stalks and leaves may be present. Sheltered to moderately wave-washed shores

W11 Marsh: cattail
Cattail-dominated marshes. Often very dense vegetation interspersed with stagnant pools. Peaty hummocks with fen species may be present. Speckled alder cover sometimes high, but usually less than 2 m tall. Ground cover usually a layer of dead stalks. Substrate is a peaty floating mat or root mat fixed to mineral soil substrate. Sheltered bays and isolated basins.

W12 Meadow marsh: tall sedge
Sedge meadow dominated by beaked sedge, water sedge, tussock sedge, lake sedge, or woolgrass. Tall shrubs sometimes present at up to 25% cover. Wetter sites have spikerush, water horsetail and more-or-less permanent pools with bladderworts and variable-leaved pondweed *(Potamogeton gramineus)*. Often with strongly tussocky microtopography. Ground cover usually a mat of sedge stems and leaves. Substrate is mineral soil or well-decomposed peat, usually with a dense root mat. Occasionally on semi-floating mat. Floodplains of small streams, beaver meadows, ditches, occasionally in isolated basins.

W13 Meadow marsh: bluejoint grass
Meadow marsh dominated by bluejoint grass, often with tall sedges. Tall shrubs sometimes present at up to 25% cover. Flat or tussocky microtopography. Ground cover a heavy mat of grass stems and leaves. Patches of bare soil present in wetter locations. Substrate is mineral soil or welldecomposed peat, usually with a dense root mat. Floodplains of small streams, beaver meadows, lakeshores.

Scientific and common names of plant species from Northwestern Ontario Wetland Ecosystem Classification and Fish Use of Wetlands factsheets[4].

Arrowheads	*Sagittaria spp.*
Beaked sedge	*Carex rostrata*
Bladderworts	*Utricularia spp.*
Bluejoint grass	*Calamagrostis canadensis*
Bulrushes	*Scirpus validus and S. acutus*
Burreeds	*Sparganium spp.*
Cattails	*Typha spp.*
Common waterweed	*Elodea canadensis*
Coontail	*Ceratophyllum demersum*
Floating-leaved burreed	*Sparganium fluctuans*
Floating-leaved pondweed	*Potamogeton natans*
Lake sedge	*Carex lacustris*
Large-leaf pondweed	*Potamogeton amplifolius*
Nodding beggar's tick	*Bidens cernua*
Pipewort	*Eriocaulon aquaticum*
Pondweeds	*Potamogeton spp.*
Reed	*Phragmites australis*
Reed canary grass	*Phalaris arundinacea*
Slender naiad	*Najas flexilis*
Speckled alder	*Alnus incana*
Spikerush	*Eleocharis smallii*
Stonewort	*Chara spp.*
Sweet flag	*Acorus calamus*
Tall manna grass	*Glyceria borealis*
Tussock sedge	*Carex stricta*
Variable-leaved pondweed	*Potamogeton gramineus*
Water horsetail	*Equisetum fluviatile*
Waterlilies	*Nymphaea spp. and Nuphar spp.*
Water lobelia	*Lobelia dortmanna*
Water milfoil	*Myriophyllum spp.*
Water parsnip	*Sium suave*
Water plantain	*Alisma plantago-aquatica*
Water sedge	*Carex aquatilis*
Water shield	*Brasenia schreberi*
Water smartweed	*Polygonum amphibium*
Wild celery	*Vallisneria americana*
Wild rice	*Zizania palustris*
Woolgrass	*Scirpus cyperinus*

[4] Hall-Armstrong, J., A.G. Harris, and R.F. Foster. 1996

APPENDIX 2: WILDLIFE VALUES[5] OF AQUATIC VEGETATION

SUBMERGENT PLANTS

- **Burreed** ***Sparganium*** **sp.**
  Seeds eaten by waterfowl (especially mallards). Whole plant is used by muskrat
  Pondweeds ***Potamogeton*** **sp.**
  Seeds and leaves of many species of pondweeds are extensively used by almost all species of ducks, geese, swans and shorebirds.
  Used to a minor extent by muskrat and moose.
- **Smartweed** ***Polygonum amphibium***
  Seeds of smartweed are extensively used by most species of ducks, geese, and swans, particularly mallard, pintail and blue-winged teal
- **Water buttercup** ***Ranunculus*** **sp.**
  Used to a minor extent by waterfowl
- **Water-starwort** ***Callitriche*** **sp.**
  Form mats which shelter aquatic organisms, eaten by waterfowl especially when water is drawn down and plants are exposed
- **Mare's Tail** ***Hippuris vulgaris***
  Used to a minor extent by waterfowl

EMERGENT PLANTS

- **Bulrushes** ***Scirpus*** **sp.**
  Used by muskrats and for nesting cover by waterfowl
- **Cattails** ***Typha*** **sp.**
  Rootstocks are used primarily by geese and muskrats
- **Spikerush** ***Eleocharis*** **sp.**
  moderately valuable to ducks and moose
- **Sedges** ***Carex*** **sp.**
  Seeds, shoots and rhizomes used to a moderate extent by waterfowl. Dense stands of sedges provide waterfowl nesting habitat. Browsed by moose and bear.
- **Willows** ***Salix*** **sp.**
  Major food source for moose, elk, deer, beaver and hare
- **Grasses** ***Calamagrostis, Deschampsia, Poa*** **spp. etc.**
- Provide nesting cover and food source to some species.

[5] Derived primarily from Martin, A. C., H. S. Zim and A.L. Nelson. 1951. American Wildlife and Plants. A Guide to Wildlife Food Habits. Dover Publications. New York.